A Spatial Pattern Analysis of Forest Loss in the Madre de Dios region, Peru

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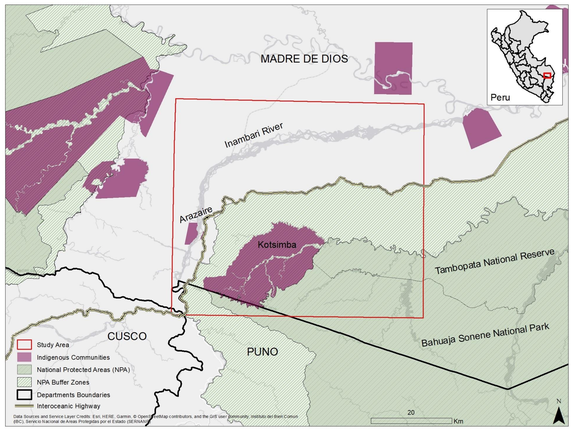
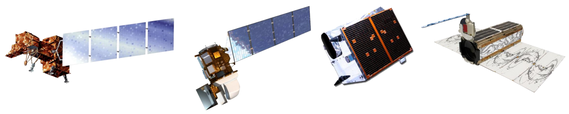
Abstract

Previous studies have quantified the expansion of gold mining-related forest loss (Espejo et al., 2018; Asner et al., 2017; Swenson et al., 2011) in the Madre de Dios region of Peru. This study uses Spectral Mixture Analysis (SMA) in a cloud-computing platform to map general forest loss within and outside key land tenure areas in this region. Landsat 7 Enhanced Thematic Mapper plus (ETM+) and Landsat 8 Operational Land Imager (OLI) Surface Reflectance data were utilized spanning 2013 and 2018 and spectral unmixing was performed to identify patterns of forest loss for each year. Planet Scope and RapidEye imagery were used to conduct an accuracy assessment and to identify potential drivers.

Study Area



Earth Observations



Landsat 8 OLI *Landsat 7 ETM+* *RapidEye* *Planet Scope*

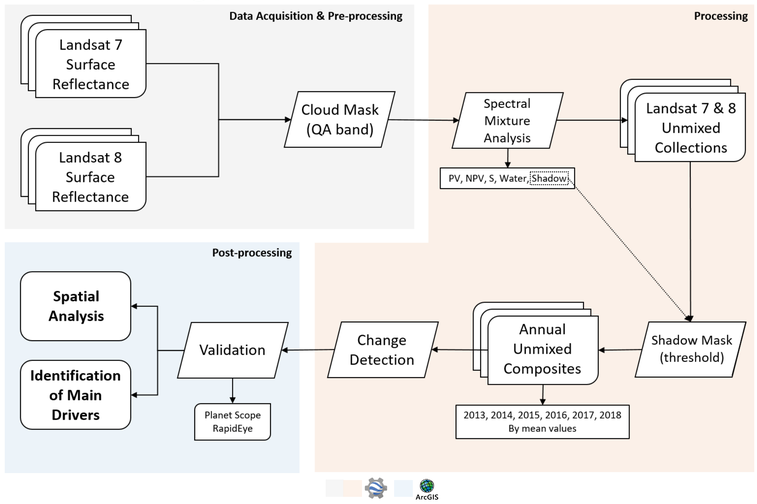
Datasets

Data – Shapefile	Source	Last updated
Mining Concessions	INGEMMET	06/19/2018
National Protected Areas (NPA)	SERNANP	02/08/2018
NPA Buffer Zones	SERNANP	06/11/2018
Indigenous Communities	Amazonia Socio Ambiental/IBC	12/2015
Reforestation Concessions	SERFOR	11/13/2017
Departments Boundaries	MINAM	No information
Interoceanic Highway	OpenStreetMap	03/2019

Objectives

- Quantify rates of forest loss within protected areas and indigenous communities
- Analyze how forest loss relates to other land tenures such as mining permits and reforestation concessions
- Identify potential drivers of forest loss to see if gold mining is the main driver and explain how these potential drivers relate to the land tenure

Methodology



- Spectral Mixture Analysis

We defined photosynthetic vegetation (PV), non-photosynthetic vegetation (NPV), water and shadow as endmembers and applied the spectral unmixing algorithm embedded in Google Earth Engine.

- Change Detection

Forest loss was based on a modified version of the algorithm applied in Asner et al., (2009) and is indicated by a decrease in 50% of the PV fraction between a post composite and a pre composite.

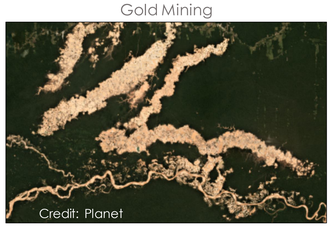
- Validation and Accuracy Assessment

For 2013, 20 scenes with 5-m resolution from RapidEye-1, RapidEye-2, RapidEye-3, and RapidEye-5 were utilized, and for 2018, 46 scenes with 3-m resolution from Planet Scope were utilized, covering the entire study area.

A stratified sampling design with 1100 randomly generated points and proportional allocation was used according to Olofsson et al. (2014) guidelines .

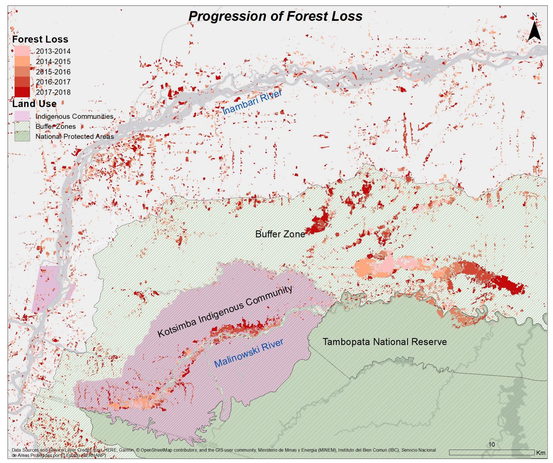
High Resolution Imagery

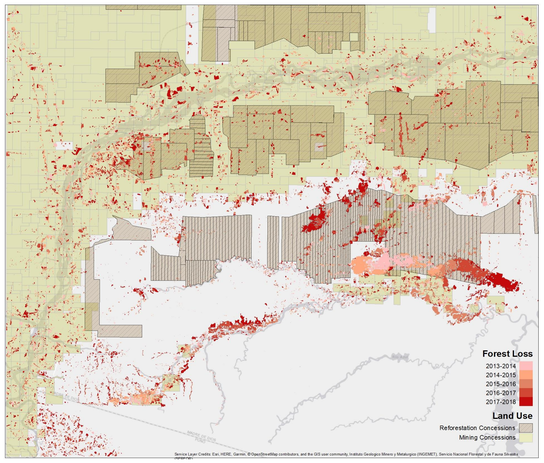
Gold Mining



Agriculture/Settlement

Results & Discussion





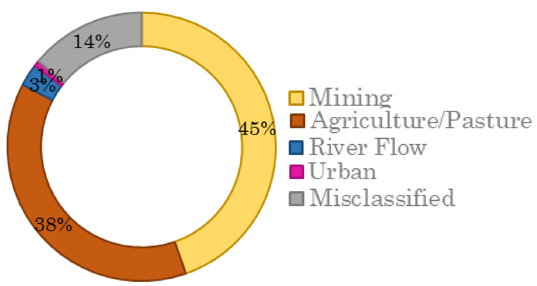
The figures above illustrate the progression of forest loss across space and time, with concentrations revealed along the Malinowski River, within the Kotsimba community, on the northern border of the Tambopata National Reserve, and within the buffer zone of the protected areas. Many possible small-scale mining sites are located alongside the Inambari river. Overall Accuracy was **96%**.

Extent and Rates (ha)

Features	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	Average Rate	Total
Reforestation Concessions	769	598	827	1402	1380	995	4976
• *Overlapping Mining and Reforestation*	*118*	*280*	*367*	*684*	*511*	*392*	*1960*
Mining Concessions	1688	1988	1755	2210	2841	2096	10482
• *Outside Mining Concessions*	*1650*	*1492*	*1628*	*2154*	*3235*	2032	10159
Kotsimba Indigenous Community	216	385	298	479	574	390	1952
Arazaire Indigenous Community	35	22	17	13	20	21	107
• *Indigenous Communities*	*251*	*407*	*315*	*492*	*594*	*412*	*2059*
Buffer Zone	1811	1838	1588	2268	3355	2172	10860
Tambopata National Reserve	48	9	379	130	39	121	605
Bahuaja-Sonene National Park	3	1	0	1	4	2	9
• *Protected Areas*	*50*	*11*	*380*	*130*	*43*	*123*	*614*
Study Area	3338	3480	3383	4364	6076	4128	20641

The average rate of forest loss in the study area between 2013 and 2018 is 4128 ha/yr Our results also suggest that approximately 49% of the forest loss lies outside the mining permits' locations.

Potential Drivers



Drivers Comparison		Potential Drivers: Gold Mining	Potential Drivers: Ag/Pasture
Median near distance to (km)	Indigenous communities	68.7	132.2
	Protected Areas	56.8	220.6
	Buffer Zone	0.0	58.2
	IOH	104.5	59.7
	Rivers	6.8	5.2
	Mining concessions	9.1	0.0
	Reforestation concessions	12.1	12.6
% of points inside	Indigenous communities	24%	2%
	Protected Areas	7%	0%
	Buffer Zone	85%	26%
	IOH	-	-
	Rivers	-	-
	Mining concessions	18%	75%
	Reforestation concessions	33%	21%

Conclusions

- Forest loss progression continues to prevail in this region, threatening specially the Kotsimba Indigenous Community
- Gold mining is not the only driver causing forest loss in the region, since Agriculture/Pasture represents 38% of the points identified
- The maps created with the use of Landsat data provide information for subsequent assessments on land cover planning and monitoring
- The use of the spectral mixture algorithm as a change detection technique provides accurate results

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